PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : B04B 11/02, 11/04

A1

(11) International Publication Number: WO 96/34693

(43) International Publication Date: 7 November 1996 (07.11.96)

(21) International Application Number: PCT/SE96/00455

(22) International Filing Date: 9 April 1996 (09.04.96)

(30) Priority Data:
9501606-9 2 May 1995 (02.05.95) SE

(71) Applicant (*for all designated States except US*): TETRA LAVAL HOLDINGS & FINANCE S.A. [CH/CH]; 70, avenue Général-Guisan, CH-1009 Pully (CH).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): AJNEFORS, Fredrik [SE/SE]; Hästhomsvägen 10, S-116 44 Stockholm (SE). SVENSSON, Börje [SE/SE]; Bohusgatan 45, S-116 67 Stockholm (SE). NORDSTRÖM, Torbjörn [SE/SE]; Jaktvägen 9, S-147 34 Tumba (SE).

(74) Agent: INGEMAR, Clivemo; Alfa Laval AB, S-147 80 Tumba (SE).

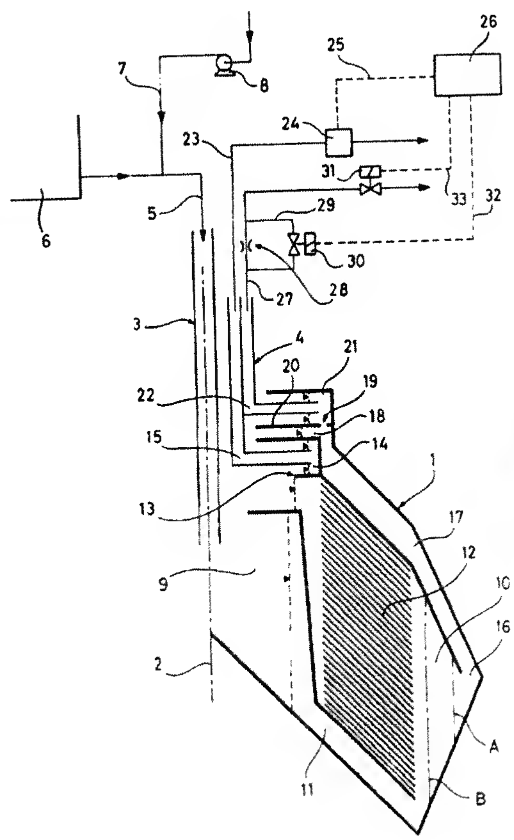
(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: METHOD AND CENTRIFUGAL SEPARATOR FOR SEPARATION OF TWO LIQUIDS

(57) Abstract

In a centrifugal rotor for separating a light liquid from a heavy liquid the separation chamber (10) has a central outlet (13) for separated light liquid and a peripheral outlet (16) for separated heavy liquid. A channel (17) in the rotor connects the peripheral outlet (16) with a central outlet (21, 22) for the heavy liquid, which latter outlet is arranged to conduct heavy liquid out of the rotor and into a stationary outlet conduit (27) for further transportation to a reception place for the heavy liquid. In the stationary outlet conduit (27) there is equipement (28-30) to make possible either a relatively large flow or a relatively small flow of separated heavy liquid from the rotor to said reception place.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	GB	United Kingdom	MW	Malawi
AT	Austria	GE	Georgia	MX	Mexico
AU	Australia	GN	Guinea	NE	Niger
BB	Barbados	GR	Greece	NL	Netherlands
BE	Belgium	HU	Hungary	NO	Norway
BF	Burkina Faso	IE	Ireland	NZ	New Zealand
BG	Bulgaria	IT	Italy	PL	Poland
BJ	Benin	JP	Japan	PT	Portugal
BR	Brazil	KE	Kenya	RO	Romania
BY	Belarus	KG	Kyrgystan	RU	Russian Federation
CA	Canada	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic			SE	Sweden
CG	Congo	KR	Republic of Korea	SG	Singapore
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LR	Liberia	SZ	Swaziland
CS	Czechoslovakia	LT	Lithuania	TD	Chad
CZ	Czech Republic	LU	Luxembourg	TG	Togo
DE	Germany	LV	Latvia	TJ	Tajikistan
DK	Denmark	MC	Monaco	TT	Trinidad and Tobago
EE	Estonia	MD	Republic of Moldova	UA	Ukraine
ES	Spain	MG	Madagascar	UG	Uganda
FI	Finland	ML	Mali	US	United States of America
FR	France	MN	Mongolia	UZ	Uzbekistan
GA	Gabon	MR	Mauritania	VN	Viet Nam

Method and centrifugal separator for separation of two liquids

The present invention relates to centrifugal separation of a light liquid and a heavy liquid from a liquid mixture containing two such liquids. The expressions "light liquid" and "heavy liquid" mean in this connection that one of the liquids has a lower or higher density, respectively, than the other liquid.

Particularly, the invention concerns separation of this kind by means of a centrifugal separator comprising a rotor having a centre axis around which it is rotatable and delimiting a separation chamber which has a first outlet for the light liquid, situated at a first distance from the rotor axis, and a second outlet for the heavy liquid, situated at a second distance, larger than the first distance, from the rotor axis, the rotor further delimiting a channel extending from said second outlet towards the rotor centre axis to a third outlet that is adapted to conduct the heavy liquid out of the rotor. The centrifugal separator also comprises a stationary outlet conduit adapted to receive liquid from said third outlet and conduct it to a reception place for heavy liquid, situated outside the centrifugal separator.

In a centrifugal separator of this kind an interface layer, that is formed in the separation chamber during operation of the rotor between separated light liquid and separated heavy liquid, has traditionally been maintained at a predetermined radial level between said first outlet and said second outlet of the separation chamber.

To constantly maintain in this manner the formed interface layer at a predetermined level in the separation chamber radially inside the outlet for heavy liquid means a disadvantage in cases when the treated liquid mixture consists mainly of light liquid that is to be freed from a relatively small amount of heavy liquid. This is because in connection with an operation of this kind the space in the separation chamber, that can be used for an effective cleaning of the light liquid, is relatively limited, meaning that the light liquid will get a reduced time for its through-flow of the separation chamber. The result of this is a less effective cleaning of the light liquid than obtainable if substantially the whole separation chamber would be kept filled with liquid mixture, i.e. mainly light liquid.

This disadvantage can be avoided in a centrifugal separator of the above discussed kind by means of an invention described in US-A-3,752,389 and residing in keeping the heavy liquid outlet of the centrifugal separator closed until so much heavy liquid has been collected in the rotor separation chamber that the formed interface layer between light liquid and heavy liquid has arrived at a predetermined level in the separation chamber radially inside said second outlet. Not until then separated heavy liquid has been allowed to leave the centrifugal separator in order to flow to a reception place for such liquid.

The centrifugal separator according to US-A-3,752,389 is formed in a way such that said interface layer, after it has arrived at said predetermined level in the rotor, cannot immediately be displaced radially outwardly but will stay at this level in spite of the fact that the outlet for heavy liquid has been opened. Only after a

separate peripheral sludge outlet of the separation chamber, intended for separated solid particles, has been opened, heavy liquid having been collected in the separation chamber can be removed therefrom.

Even the separation method and the centrifugal separator according to US-A-3,752,389 proved to be disadvantageous, however. Thus, even if a large part of the separation chamber could be used effectively, in the manner just described, during a larger part of the operation time of the rotor than in connection with previously known centrifugal separators, the disadvantage was still there that such an effective use of the separation chamber could not be made during time running from the moment when the interface layer between light liquid and heavy liquid had arrived at said predetermined level to the moment when the peripheral rotor sludge outlet for separated solids had been opened. This time could be relatively long, if the content of solids in the treated liquid mixture was relatively small, whereas the content of heavy liquid was much larger.

The technique according to US-A-3,752,389 has later been improved in a way that can be seen from US-A-4,525,155. The improvement resides in creation of an arrangement by means of which said interface layer between light liquid and heavy liquid cannot only be allowed to move radially inwardly to a certain level in the separation chamber radially inside the outlet for heavy liquid but also, immediately thereafter, can be allowed to move radially outwardly a distance as a consequence of the outflow of heavy liquid through said outlet just mentioned. This has generated more time for an effective use of a large part of the separation chamber.

As mentioned initially the invention according to US-A-3,752,389 was made to resolve a problem when a liquid mixture to be treated consisted mainly of light liquid that should be freed from a relatively small amount of heavy liquid. Even the improvement according to US-A-4,525,155 was primarily intended for separation cases of this kind. If the content of heavy liquid in the liquid mixture to be supplied to the rotor is relatively large, it is obvious, namely, that the advantage of the proposed movement of the interface layer between light liquid and heavy liquid becomes relatively small. In other words the time during which the relevant part of the separation chamber can be used for effective separation will be smaller and smaller the more rapidly the interface layer moves radially inwardly and, thus, heavy liquid fills the separation chamber.

It has shown, thus, in a particular separation application for the invention according to US-A-4,525,155, namely in connection with cleaning of fuel oil from water and solids, that the fuel oil to be cleaned should not have an average content of water larger than about 3 % for the invention in question to give a substantial advantage above the initially mentioned traditional technique, according to which the interface layer in the separation chamber is maintained constantly at the same radial level in the separation chamber. If there are larger contents of water in the fuel oil to be cleaned, the traditional technique, which as mentioned was known already before the invention according to US-A-3,752,389 was made, is therefore still used.

The present invention has for its object to provide a new method and a new centrifugal separator for the separation of a light liquid and a heavy liquid from a

liquid mixture containing two such liquids and having a relatively large content of heavy liquid, so that the separation chamber in the rotor of the centrifugal separator can be used more effectively than in connection with conventional use of a centrifugal separator when an interface layer is maintained constantly at a predetermined radial level in the separation chamber.

This object can be obtained according to the invention by means of a method using a centrifugal separator of the general kind defined initially and including supplying said liquid mixture into the separation chamber; sensing when an interface layer, which during the rotor operation is formed in the separation chamber between light liquid and heavy liquid and moves towards the centre axis of the rotor as a consequence of accumulation of separated heavy liquid in the separation chamber, arrives at a predetermined distance from the centre axis; intermittently conducting out of the rotor an outlet flow of liquid through said third outlet and the stationary outlet conduit to the reception place for heavy liquid, the conducting of said outlet flow starting when said interface layer has arrived at said predetermined distance from the rotor centre axis, so that the interface layer in the separation chamber instead moves away from the rotor centre axis; and stopping said outlet flow of liquid from said third outlet to the reception place for heavy liquid; said method being characterized by conducting a drainage flow of separated heavy liquid, which is substantially smaller than said outlet flow, out of the rotor through said third outlet to a reception place outside the centrifugal separator during at least part of time when said outlet flow is not conducted out of the rotor through said third outlet.

By the expression reception place for separated heavy liquid, situated outside the centrifugal separator, is meant a reception place from which the separated heavy liquid is not returned to the rotor of the centrifugal separator.

A centrifugal separator according to the invention is characterized in that it comprises

- a rotor having a centre axis around which it is rotatable and delimiting a separation chamber which has a first outlet for the light liquid, situated at a first distance from the rotor centre axis, and a second outlet for the heavy liquid, situated at a second distance, larger than said first distance, from the rotor centre axis, the rotor further delimiting a channel extending from said second outlet towards the rotor centre axis to a third outlet, which is adapted to conduct the heavy liquid out of the rotor,

- a stationary outlet conduit adapted to receive liquid from said third outlet and conduct it to a reception place for heavy liquid, situated outside the centrifugal separator,

- sensing means adapted to sense and emit a control signal when an interface layer, which during the rotor operation has been formed in the separation chamber between light liquid and heavy liquid and which moves towards the rotor centre axis as a consequence of accumulation of separated heavy liquid in the separation chamber, has arrived at an inner radial level situated at a predetermined distance from the centre axis,

- outlet means connected with the sensing means and adapted, when the latter emit said signal, to be caused to provide an outlet flow of liquid from said third outlet through the stationary outlet conduit to the reception place for heavy liquid, so that said interface layer in the separation chamber moves away from the rotor centre axis, and

- means for interrupting said outlet flow of liquid from said third outlet to the reception place for heavy liquid, when said interface layer in the separation chamber has arrived at an outer radial level situated between said inner level and said second outlet.

A centrifugal separator according to the invention is further characterized in

- that there is no connection radially inside said outer radial level between the separation chamber and said channel, so that the channel is kept filled with separated heavy liquid, when said outlet flow is interrupted, and

- that draining means are adapted to accomplish, at least during part of such time when the outlet means do not not accomplish said outlet flow of liquid, a drainage flow of separated heavy liquid from said third outlet out of the rotor to a reception place outside the centrifugal separator, said drainage flow being substantially smaller than said outlet flow.

In a centrifugal separator of this kind said draining means may be caused to conduct so much heavy liquid out

of the rotor that the movement radially inwardly in the separation chamber of said interface layer is substantially delayed. Thereby, during large parts of the operation time of the centrifugal separator, such parts of the separation chamber may be used for effective separation which have not been used at all for effective separation in connection with conventional separation technology but have been kept filled with separated heavy liquid. The same advantages as offered by the invention according to US-A-4,525,155 only in connection with cleaning of a light liquid, which contains less than 3 % of heavy liquid, can thus be obtained by means of the present invention in connection with cleaning of light liquid having a substantially larger content of heavy liquid, e.g. 10 % or more.

In connection with cleaning of fuel oil from water and solids by means of a centrifugal separator additional water is sometimes added to the fuel oil before the latter is supplied to the centrifugal separator. The purpose thereof is that certain salts, present in the fuel oil, should be solved in the added water and together therewith be separated from the fuel oil in the centrifugal separator. Such addition of so called wash water to the fuel oil makes the total water content therein to be at about 8-10 %.

In a centrifugal separator according to the present invention said draining means may be adapted to discharge water from the above said third outlet of the rotor in an amount having a desired relation to the amount of wash water added to the fuel oil before the fuel oil is introduced in the centrifugal separator. However, the draining means must not discharge a larger

amount of water from the rotor than the amount of wash water being added to the fuel oil.

In the centrifugal separator according to the invention said sensing means for sensing when the interface layer has arrived at a predetermined radial level in the separation chamber can be designed in any suitable way. If desired, the separation chamber may be provided with a further outlet at a suitable radial level, whereby continuously or intermittently a small liquid flow may be discharged from the separation chamber at this level and automatically be analyzed outside the rotor.

Preferably, sensing means of the kind described in US-A-4,525,155 are used, which are adapted to sense when small fractions of a heavy liquid starts to accompany separated light liquid out of the rotor. Sensing like this, e.g. sensing of changes of the electrical conductivity or dielectric constant of the inspected liquid, indicates that the interface layer between light and heavy liquid has arrived at a certain radial level in the separation chamber.

Other sensing means, e.g. of the kind described in US-A-3,189,268 or US-A-3,986,663, are also possible in this connection.

The sensing means are preferably adapted to emit an electrical control signal when said interface layer is sensed at the predetermined radial level in the separation chamber. Other types of control signals, such as magnetical or optical, are alternatively possible, however.

The outlet means, which are connected to the sensing means and arranged to receive the above said control signal from the sensing means and then accomplish the relatively large outlet flow from the third outlet of the rotor to the reception place for heavy liquid, preferably comprise an adjustable valve arranged in the stationary outlet conduit, which is adapted to receive liquid from said third outlet. An adjustable valve of this kind may be arranged either completely to interrupt the liquid flow through the stationary outlet conduit or, when it does not hold open for the relatively large liquid flow, admit through-flow of a relatively small flow. In the latter case the valve itself comprises said draining means, which are to accomplish the relatively small drainage flow, whereas in the first mentioned case there have to be arranged draining means separate from the valve, e.g. in a by-pass conduit arranged to conduct liquid past the valve in the stationary outlet conduit. For interrupting the relatively large outlet flow of liquid from the third outlet of the rotor one kind of actuation member or another is used and arranged for adjustment of said valve.

For accomplishing the relatively large outlet flow of liquid the centrifugal separator may alternatively be equipped with outlet means comprising a radially movable paring member. A paring member of this kind may be arranged to be brought into contact with the body of separated heavy liquid rotating in the rotor only when the relatively large outlet flow is to leave the rotor. In this case said member for interrupting the outlet flow can be constituted by a device for radially moving the paring member to or from contact with said liquid body. A separate outlet means comprising said draining

means can be present for accomplishing said relatively small drainage flow.

As mentioned above the relatively large outlet flow through the third outlet of the rotor will give as a result that the interface layer in the separation chamber between light liquid and heavy liquid moves radially outwardly. Preferably, the outlet flow out of said third outlet is stopped before the interface layer has arrived out at said second outlet of the separation chamber. Thereby, it is prevented that separated light liquid leaves the separation chamber through this outlet. If by accident - or if the centrifugal separator is designed in a way that - separated light liquid during certain periods of time leaves the separation chamber through said second outlet, means may be arranged to automatically sense that light liquid flows out through the third outlet of the rotor and to automatically discharge such liquid to a particular reception place. A reception place of this kind could be a container for liquid mixture not yet treated. Alternatively, the liquid may be conducted directly into the inlet conduit of the centrifugal separator for liquid mixture to be treated.

Interruption of the relatively large outlet flow through the third outlet of the rotor may be accomplished automatically either after expiration of a predetermined set time or after a predetermined amount of liquid has left the third outlet of the rotor, counted from the point of time when the outlet flow started. A device for automatically interrupting the relevant flow from the third outlet of the rotor is described in US-A-4,525,155.

The invention will be described more in detail below with reference to the accompanying drawing in connection with a process for washing fuel oil by means of water and cleaning of the fuel oil from water and suspended solids. In a washing and cleaning process of this kind water is added to the fuel oil in connection with supplying of the latter to a centrifugal separator, salts present in the fuel oil being solved in the water and together therewith being separated from the fuel oil in the centrifugal separator. The separated water contains both water added to the fuel oil for the washing, and water contained by the fuel oil before the addition of wash water. In the drawing Fig 1 and 2 show different embodiments of the invention.

Fig 1 shows schematically one half of a centrifugal rotor 1 seen in an axial section. The rotor 1 is adapted to rotate around a centre axis 2. A stationary inlet pipe 3 extends into the rotor and is surrounded by a likewise stationary outlet member 4.

The stationary inlet pipe 3 is connected with an inlet conduit 5, which starts from a container 6 containing fuel oil. The inlet conduit 5 is connected to a wash water supply conduit 7, which is arranged to receive a predetermined flow of wash water from a pump 8.

The rotor 1 delimits a central receiving chamber 9, in which the inlet pipe 3 opens. The rotor further delimits a separation chamber 10, which communicates with the reception chamber 9 through several channels 11 distributed around the rotor centre axis 2. In the separation chamber 10 there is arranged a stack of frusto-conical separation discs 12 arranged concentrically with the rotor and at short axial distances from each other.

The separation chamber 10 has a central first outlet 13 for separated fuel oil, situated at a certain distance from the centre axis 2. This outlet 13 of the separation chamber 10 has the form of an overflow outlet, which opens into a first central outlet chamber 14. A so called paring member 15, which constitutes part of said stationary outlet member 4, is adapted to conduct the separated fuel oil out of the outlet chamber 14.

The separation chamber 10 has a second outlet 16 situated at a larger distance from the centre axis 2 than the central first outlet 13. The outlet 16 is intended for water having been separated from the fuel oil and salts solved in this water.

The rotor 1 delimits several channels 17 distributed around the rotor centre axis 2 and extending from said second outlet 16 in a direction towards the centre axis 2. The channels 17 open in an annular space 18 in the rotor. This space 18 communicates through one or more calibrated openings 19 in an annular partition 20 with a second outlet chamber 21 delimited in the uppermost part of the rotor. A paring member 22, which like the paring member 15 forms part of the stationary outlet member 4, is adapted to conduct separated water out of the outlet chamber 21.

An outlet conduit 23 is coupled to the paring member 15 intended for separated fuel oil. This outlet conduit is adapted to conduct the separated fuel oil through an instrument 24 for sensing when in the passing fuel oil it starts to appear fractions of water having been entrained in the fuel oil from the rotor. The instrument 24 may for instance comprise a capacitor between the electrodes of which the flow through the outlet conduit

23, or part of this flow, is allowed to pass. A change of the dielectric constant of the flowing fuel oil may be sensed in this way. The dielectric constant of clean fuel oil is in the order of about 2, whereas for clean water it is in the order of 80, so even a very small content of water in the fuel oil may be sensed in this way.

The instrument 24 is adapted to emit a signal through a signal line 25 to a central control unit 26, when a predetermined content of water is sensed in the passing fuel oil.

To the paring member 22 for separated water there is connected an outlet conduit 27, which opens at a reception place (not shown) for separated water. In the outlet conduit 27 there is placed a draining member in the form of a throttling nozzle 28 adapted to accomplish a relatively small flow of liquid through the outlet conduit 27.

In a by-pass conduit 29, which is connected to the outlet conduit 27 upstream and downstream of the throttling nozzle 28, there is placed a valve 30. The valve 30 in a closed position is adapted to prevent flow through the by-pass conduit 29 and in an open position to accomplish a flow through the by-pass conduit 29 and, thereby, through the outlet conduit 27, which is substantially larger than the flow which can be accomplished through the throttling nozzle 28.

After the throttling nozzle 28 and the valve 30, seen in the flow direction, the outlet conduit 27 has a closing valve 31.

Both valves 30 and 31 are connected through signal lines 32 and 33, respectively, with the central control unit 26.

In the separation chamber 10 of the rotor it has been shown two dash-dot lines A and B. These lines intend to indicate two different radial levels in the separation chamber. Free liquid surfaces being formed in different parts of the rotor during operation are illustrated in the drawing by small triangles.

The centrifugal separator according to the invention operates in the following manner.

Through the inlet pipe 3 a liquid mixture containing about 90 % fuel oil and about 10 % water enters the receiving chamber 9 of the centrifugal rotor. The liquid mixture is conducted through the channels 11 into the separation chamber 10, in which the water is separated from the fuel oil. Certain salts having been present in the fuel oil have become solved in the water while the liquid mixture was on its way into the rotor and are, thus, parts of the water separated in the separation chamber.

In a starting position the valve 31 is closed, so that no liquid can leave the rotor through the outlet conduit 27. In the separation chamber 10 there is formed an interface layer between the separated water and the fuel oil having been freed from such water. This interface layer moves radially inwardly in the separation chamber 10 and reaches relatively soon the level A. At this stage the valve 31 is opened, whereupon separated water starts to flow from the separation chamber 10 through the channels 17, the space 18, the openings 19, the

outlet chamber 21 and the paring member 22 to the outlet conduit 27. In the starting position also the valve 30 is closed and, therefore, the water passes through the throttling nozzle 28 and further on out through the outlet conduit 27.

It is possible to have the valve 31 open even at the beginning of the separation process, but in such a case it is suitable to fill part of the separation chamber 10 with only water, before a mixture of fuel oil and water is introduced into the rotor.

Said throttling nozzle 28 preferably is dimensioned such that the flow of water through the outlet conduit 27 does not exceed the supply of water through the conduit 7. It is thus the throttling nozzle 28 that, at this stage of the separating operation, should limit the water flow out of the rotor 1. This means that the opening or openings 19 in the partition 20 of the rotor have to be sufficiently large to allow a water flow of this kind from the space 18 to the outlet chamber 21. Further, this means that the free liquid surfaces having been formed in the outlet chamber 21 and in the space 18 will be present at substantially the same radial level in the rotor. This radial level will determine the magnitude of the liquid pressure prevailing in the outlet conduit 27 upstream of the throttling nozzle 28. The through-flow opening of the throttling nozzle, thus, must be dimensioned with regard to the expected position of the liquid surfaces in the space 18 and the outlet chamber 21.

While separated water leaves the rotor through the outlet conduit 27, separated or cleaned fuel oil flows over the overflow outlet 13 out into the outlet chamber

14. Thence the fuel oil is continuously discharged by means of the paring member 15 and leaves the centrifugal separator through the outlet conduit 23. On its way the fuel oil passes through the sensing instrument 24, which senses whether the fuel oil contains more or less than a predetermined content of water.

As the separation operation proceeds the interface layer between fuel oil and water in the separation chamber 10 will move from the level A radially inwardly. The reason for this is above all that the fuel oil in the container 6 has, as a rule, a certain content of water, e.g. about 1 %, but also that, for the sake of safety, the supply of water through the inlet conduit 7 is kept somewhat larger than the water flow discharged through the outlet conduit 27. Substantially all of the water supplied to the rotor is separated from the fuel oil in the separation chamber 10, and since only part of the same is discharged through the outlet conduit 27 the rest is accumulated in the radially outer part of the separation chamber.

When the interface layer between fuel oil and water has arrived at the level B, small fractions of water begin to accompany the fuel oil inwardly through the stack of separation discs 10 and leave the rotor through the outlet conduit 23 together with the fuel oil. When the sensing instrument 24 senses that the content of water in the fuel oil exceeds a predetermined value, e.g. 0,1 %, it emits a signal to the control unit 26, from where a control signal goes through the signal line 32 for opening of the valve 30. The valve 30 as well as the by-pass conduit 29 are dimensioned to allow a flow therethrough, which is substantially larger than the flow which has earlier passed through the throttling

nozzle 28. Thus, water now starts to flow out of the outlet chamber 21 through the outlet conduit 27 at a larger speed than before. The opening or openings 19 in the partition 20 of the rotor will now be limiting for the flow that can pass from the space 18 into the outlet chamber 21. Since the opening or openings 19 will now throttle the supply of water to the outlet chamber 21, whereas the water flow through the paring member 22 and the outlet conduit 27 is no longer throttled, the free liquid surface in the outlet chamber 21 will move radially outwardly and be positioned at a level in the vicinity of the radially outermost part of the paring member 22, as can be seen from fig 1.

The flow of water thus now created, which leaves the separation chamber 10 through the outlet 16 and is conducted out of the rotor through the channels 17, the space 18, the calibration opening or openings 19 and the outlet chamber 21, is larger than the flow of water entering the rotor through the conduit 7 and together with fuel oil from the container 6. This means that the accumulated amount of separated water in the separation chamber 10 decreases. Consequently the interface layer between fuel oil and water moves radially outwardly in the separation chamber 10.

After a predetermined period of time, set in the control unit 26 with regard to the size of the estimated water flow out of the rotor, the valve 30 in the by-pass conduit 29 is again closed. Then the movement radially outwardly of the interface layer in the separation chamber stops. The predetermined period of time is chosen such that the movement radially outwardly of the interface layer stops while the outlet 16 is still completely covered by separated water in the separation

chamber, so that no fuel oil flows out of the separation chamber through the outlet 16.

The separating operation can then be continued in a manner as described before, until the sensing instrument 24 again senses the predetermined content of water in the cleaned fuel oil and again opens the valve 30.

Normally the centrifugal separator schematically shown in the drawing is of a kind making possible intermittent opening of peripheral so called sludge outlets in the rotor for discharging from the separation chamber relatively heavy solids separated therein. A centrifugal separator of this kind is well known and, therefore, said sludge outlets are not shown in the drawing. An example of a centrifugal rotor provided with sludge outlets of this kind is shown in US 4,525,155.

As can be seen from fig 1, the free liquid surface in the space 18 is situated at a somewhat larger distance from the rotor centre axis 2 than the free liquid surface in the separation chamber 10, i.e. the overflow outlet 13. The reason for this is above all that the fuel oil and the water in the separation chamber 10 have different densities. Thus, the radial liquid column present in the channels 17 and the space 18 and consisting of only water shall balance the radial liquid column which is present in the separation chamber 10 between the overflow outlet 13 and the outlet 16 and which consists of both fuel oil and water. Depending upon the radial position of the interface layer formed in the separation chamber between fuel oil and water the free liquid surface in the space 18 may thus take somewhat different positions. The closer the said interface layer is to the rotor centre axis 2, the closer to the

same centre axis is also the liquid surface in the space 18. The position of the free liquid surface in the space 18 can be influenced not only by changes of the position of the interface layer in the separation chamber but also by possible changes of the densities of the water and the fuel oil. These may vary for instance by temperature.

Since, as just described, the liquid surface in the space 18 can move radially inwardly or outwardly for different reasons, an unchanged flow through the throttling nozzle 28, or through the opening or openings 19 when the valve 30 is open, cannot always be maintained. In order to make possible greater security in the correspondence between the water flows into the rotor through the rotor conduit 7 and out of the rotor through the outlet conduit 27 an arrangement of valves according to fig 2 can be used.

Fig 2 shows a centrifugal rotor differing from the one shown in fig 1 in some respects. The same numeral references shown in fig 1 have been used in fig 2 for details corresponding to each other in fig 1 and fig 2.

In the rotor in fig 2 the channels 17 open at their radially inner ends directly in the outlet chamber 21a, in which the paring member 22 is placed. The paring member is, as in fig 1, connected to the outlet conduit 27.

In the outlet conduit 27 there is inserted a reversing valve 34, which in a first position, as shown in fig 2, is adapted to conduct liquid from the paring member 22 to a first branch conduit 27a and, in another position, conduct liquid from the paring member 22 to a second

branch conduit 27b. In the branch conduit 27a there is arranged a first valve 35 (instead of the throttling nozzle 28 in fig 1), and in the branch conduit 27b there is arranged a second valve 36 (instead of the closing valve 30 in fig 1). Both valves 35 and 36 are so called constant flow valves, i.e. each one of them is adapted to admit therethrough an unchanged liquid flow independent of occurring liquid pressure changes in the outlet conduit 27 upstream of the respective valves. The liquid pressure downstream of the respective valves 35 and 36 is supposed to be substantially constant. The branch conduits 27a and 27b join again downstream of the valves 35 and 36.

The valve 35 is dimensioned and adjusted to let through a liquid flow that is substantially smaller than that which the valve 36 is dimensioned and adjusted to let through.

The valve 34 is connected through a signal line 37 to the control unit 26a.

The arrangement according to fig 2 is intended to operate in the following manner.

As long as the interface layer in the separation chamber 10 is situated radially outside the level B but radially inside of the outlet 16, the valve 34 conducts water from the paring member 22 through the valve 35. A relatively small constant water flow then leaves the rotor through the outlet conduit 27. When the interface layer has moved radially inwardly and reached the level B, and the sensing equipment 24 has sensed that the content of water in the cleaned fuel oil has exceeded the predetermined value, the valve 34 is reversed so that water is

instead conducted through the valve 36. Then a larger constant water flow will leave the rotor through the outlet conduit 27. After a predetermined period of time, when a predetermined amount of water has thus left the rotor, the valve 34 is again reversed, so that water is conducted through the valve 35.

The previously mentioned peripheral sludge outlets (not shown) may be opened briefly at any desired frequency or when a certain amount of separated solids has been collected in the separation chamber. The control unit 26 (or 26a) may be adapted to open the sludge outlets at certain time intervals, e.g. three times an hour, or after a number of times that the valve 30 (or 36) has been in use.

Constant flow valves of the kind mentioned above are well known in many different designs and, therefore, are not described here in detail. A constant flow valve is normally adapted to automatically control the liquid flow therethrough on the basis of pressure values sensed upstream or downstream, or both upstream or downstream, of the constant flow valve.

If, in the above described example, the supply of wash water to the fuel oil through the inlet conduit 7 is intended to be adjustable or controllable, e.g. by means of the pump 8, a signal connection may be present between for instance the pump 8 and the constant flow valve 35, so that the latter is automatically adjusted for a changed constant flow depending upon the flow through the conduit 7.

By means of the above described invention the part of the separation chamber 10 situated between the levels A

and B may be utilized for effective separation of incoming fuel oil during a large part of the centrifugal separator´s operating time, even if the fuel oil contains a relatively large but varying content of water. By thorough checking of the amounts of water, which are actively supplied to the fuel oil and discharged from the centrifugal rotor, the separation chamber may be utilized effectively during the largest possible part of the separation time. A valve arrangement according to fig 2 may be used for such checking.

If desired, a centrifugal separator according to fig 1 may be modified only such that the throttling nozzle 28 is substituted by a constant flow valve 35 (according to fig 2). A constant flow valve 35 of this kind used in an arrangement according to fig 1 need not be controlled but can be kept open for through-flow all the time. Then there remains a certain inaccuracy regarding the intermittent water outflows through the valve 30, whereas a good accuracy is obtained regarding the water outflow during the main part of the separation time.

In a valve arrangement according to fig 1 the calibration function, given by the opening or openings 19, may alternatively be obtained by means of a flow limiting calibration opening in the by-pass conduit 29 or in the valve 30 in its open position. In this case there is no annular partition 20 in the rotor according to fig 1, like in the rotor according to fig 2.

In the arrangement according to fig 2 the water flow through the valve 35 - and when relevant through the valve 36 - becomes independent of density changes of the fuel oil and independent of movements, during the separation, of the free liquid surfaces or the interface

layer in the separation chamber between fuel oil and water.

Claims

1. Method of separating a light liquid having a first density and a heavy liquid having a second density larger than said first density from a liquid mixture by means of a centrifugal separator comprising

- a rotor (1) having a centre axis (2) around which it is rotatable and delimiting a separation chamber (10) which has a first outlet (13) for the light liquid, situated at a first distance from the rotor centre axis (2), and a second outlet (16) for the heavy liquid, situated at a second distance, larger than the first distance, from the rotor centre axis (2), the rotor further delimiting a channel (17) extending from said second outlet towards the rotor centre axis to a third outlet (21,22) that is adapted to conduct the heavy liquid out of the rotor, and

- a stationary outlet conduit (27) adapted to receive liquid from said third outlet (21,22) and to conduct it to a reception place for heavy liquid, situated outside the centrifugal separator,

said method including

- supplying said liquid mixture into the separation chamber (10),

- sensing when an interface layer, which during operation of the rotor is formed in the separation chamber (10) between light liquid and heavy liquid and moves towards the rotor centre axis (2) as a consequence of accumulation of separated heavy

liquid in the separation chamber (10), arrives at a predetermined distance (B) from the centre axis (2);

- intermittently conducting from the rotor an outlet flow of liquid through said third outlet (21,22) and said stationary outlet conduit (27) to the reception place for heavy liquid, the conducting of the outlet flow being started when said interface layer has arrived at said predetermined distance (B) from the rotor centre axis, so that the interface layer in the separation chamber instead moves away from the rotor centre axis (2); and

- interrupting said outlet flow of liquid from said third outlet (21,22) to the reception place for heavy liquid,

c h a r a c t e r i z e d b y

conducting a drainage flow of separated heavy liquid, which drainage flow is substantially smaller than said outlet flow, out of the rotor (1) through said third outlet (21,22) to a reception place outside the centrifugal separator during at least a part of such time when said outlet flow is not conducted out of the rotor through said third outlet.

2. Method according to claim 1, including supplying a predetermined flow of heavy liquid to be separated by means of the centrifugal separator into the separation chamber (10) together with relatively light liquid possibly containing further amounts of heavy liquid, said drainage flow conducted out of the rotor through said third outlet (21,22) to a reception place outside

the centrifugal separator being maintained at a magnitude such that it is at the most as large as said predetermined flow of heavy liquid supplied into the separation chamber (10).

3. Centrifugal separator for separating a light liquid having a first density and a heavy liquid having a second density larger than said first density from a liquid mixture, comprising

- a rotor (1) having a centre axis (2) around which it is rotatable and delimiting a separation chamber (10) which has a first outlet (13) for the light liquid, situated at a first distance from the rotor centre axis (2), and a second outlet (16) for the heavy liquid, situated at a second distance larger than the said first distance from the rotor centre axis (2), the rotor further delimiting a channel (17) extending from said second outlet (16) towards the rotor centre axis to a third outlet (21,22) that is adapted to conduct the heavy liquid out of the rotor.

- a stationary outlet conduit (27) adapted to receive liquid from said third outlet (21,22) and to conduct it to a reception place for heavy liquid situated outside the centrifugal separator,

- sensing means (24) adapted to sense and to emit a control signal when an interface layer, which has been formed during the rotor operation in the separation chamber (10) between light liquid and heavy liquid and which moves towards the rotor centre axis (2) as a consequence of accumulation of separated heavy liquid in the separation chamber,

has arrived at an inner radial level (B) situated at a predetermined distance from the centre axis (2),

- outlet means (30;34,36) connected with the sensing means (24) and adapted, when the latter emits said signal, to be caused to provide an outlet flow of liquid from said third outlet (21,22) through the stationary outlet conduit (27) to the reception place for heavy liquid, so that said interface layer in the separation chamber (10) moves away from the rotor centre axis (2), and

- means (26;2a) for interrupting said outlet flow of liquid from said third outlet (21,22) to the reception place for heavy liquid, when said interface layer in the separation chamber has arrived out at an outer radial level situated between said inner level (B) and said second outlet (16),

c h a r a c t e r i z e d i n

- that there is no connection radially inside said outer radial level between the separation chamber (10) and said channel (17), so that the channel (17) is kept filled with separated heavy liquid, when said outlet flow is interrupted, and

- that draining means (28;35) are adapted to accomplish, at least during part of such time when the outlet means (30;34,36) do not accomplish said outlet flow of liquid, a drainage flow of separated heavy liquid from said third outlet (21;22) out of the rotor to a reception place outside the centrifugal separator, said drainage flow being substantially smaller than said outlet flow.

4. Centrifugal separator according to claim 3, in which said outlet means (30;34,36) comprise a valve (30;36) arranged in said stationary outlet conduit (27).

5. Centrifugal separator according to claim 4, in which a conduit, which extends from a place upstream to a place downstream of said valve (30;36) in the stationary outlet conduit (27), forms or comprises a throttling means (28;35) for limiting of the flow through the stationary outlet conduit (27), when the valve (30;36) is not used to provide said outlet flow.

6. Centrifugal separator according to claim 3, in which said draining means comprise a constant flow valve (35) adapted to let through, in a way known per se, a predetermined liquid flow independent of the magnitude of an overpressure of liquid present upstream of the constant flow valve.

7. Centrifugal separator according to any one of claims 3-6, in which said outlet means comprise a constant flow valve (36) adapted to let throughm, in a manner known per se, a predetermined liquid flow independent of the magnitude of an overpressure of liquid present upstream of the constant flow valve.

8. Centrifugal separator according to any one of claims 3-7, in which

- first supply means (5) are adapted to supply said liquid mixture to the rotor (1),

- the rotor forms a receiving chamber (9) for receiving said liquid mixture,

- second supply means (7) are adapted to supply to the centrifugal separator a predetermined flow of heavy liquid to be separated from the liquid mixture in the centrifugal separator, and

- draining means (28;35) are adapted to accomplish said drainage flow of separated heavy liquid from said third outlet (21,22) out of the rotor to the reception place for heavy liquid, said drainage flow being at the most as large as said predetermined flow of heavy liquid that is supplied to the centrifugal separator through said second supply means (7).

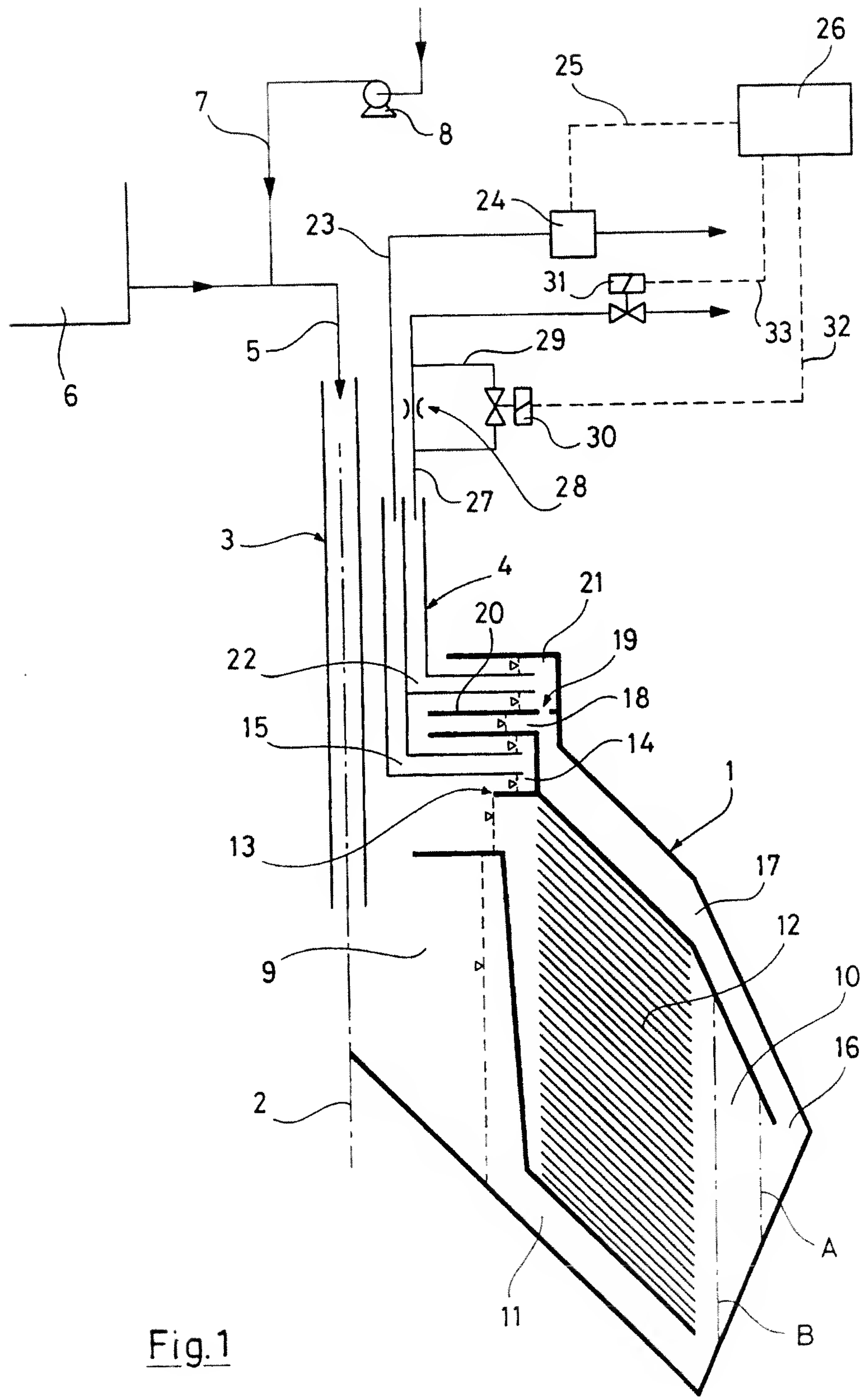

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
A
B

Fig.1

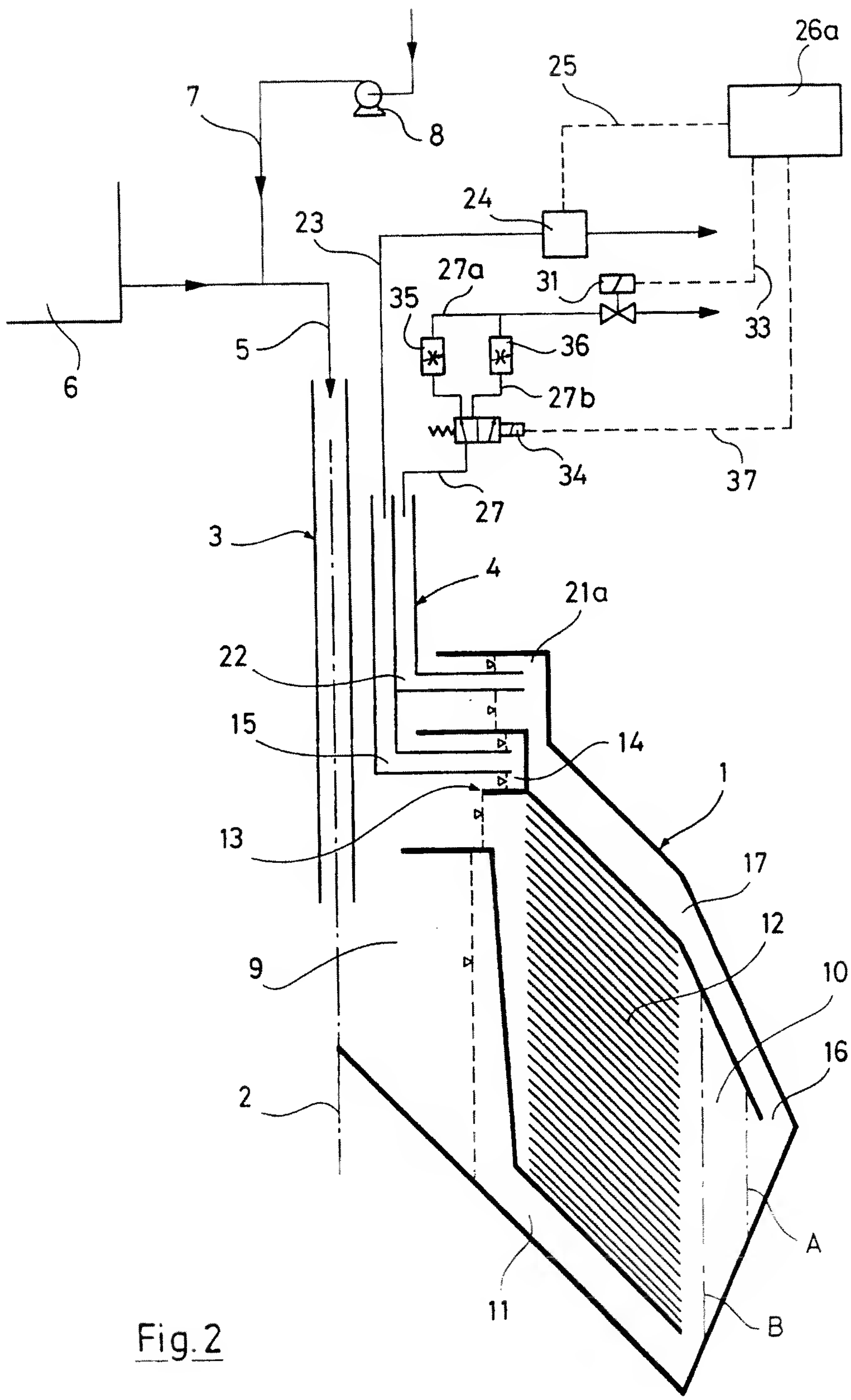

26a
25
7
8
24
23
27a
31
35
33
36
6
5
27b
34
37
27
3
4
21a
22
15
14
1
13
17
12
9
10
16
2
A
11
B

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 96/00455

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B04B 11/02, B04B 11/04
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SE 440487 B (ALFA-LAVAL MARINE & POWER ENGINEERING), 5 August 1985 (05.08.85), page 2, line 22 - line 24; page 6, line 6 - line 15, figures 1,2 --	1,3
A	US 4525155 A (VILGOT NILSSON), 25 June 1985 (25.06.85), figure 1, claims 1,13, abstract --	1,3
A	SE 502309 C2 (WESTFALIA SEPARATOR AG), 2 October 1995 (02.10.95), figure 1, abstract --	1,3

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 Sept 1996	17 -09- 1996
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	**Authorized officer** Johan von Döbeln Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 96/00455

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9112081 A1 (WESTFALIA SEPARATOR AKTIENGESELLSCHAFT), 22 August 1991 (22.08.91), figure 1, claims 1-6, abstract -- --------	1,3

INTERNATIONAL SEARCH REPORT

31/07/96

International application No.
PCT/SE 96/00455

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
SE-B- 440487	05/08/85	CA-A,A- 1248928	17/01/89
		DE-A- 3469412	31/03/88
		EP-A,A,B 0148598	17/07/85
		JP-C- 1444040	08/06/88
		JP-A- 60153960	13/08/85
		JP-B- 62054549	16/11/87
		SE-A,D- 8307075	22/06/85
		SU-A,A- 1572402	15/06/90
		US-A- 4622029	11/11/86
US-A- 4525155	25/06/85	CA-A,A- 1236065	03/05/88
		DE-A- 3473569	29/09/88
		EP-A,A,A 0123491	31/10/84
		SE-T3- 0123491	
		JP-C- 1636468	31/01/92
		JP-B- 2048307	24/10/90
		JP-A- 59199066	12/11/84
		RU-C- 2010611	15/04/94
		SE-D- 8302215	00/00/00
SE-C2- 502309	02/10/95	NONE	
WO-A1- 9112081	22/08/91	DE-C,C- 4004459	07/03/91
		DE-D- 59101726	00/00/00
		EP-A,A,B 0515396	02/12/92
		SE-T3- 0515396	
		US-A- 5267937	07/12/93